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Patentanmeldung Nr. | Patent application No. | Demande de brevet n°

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COMBINED SEPARATION AND STRIPPING PROCESS

Background of the invention

The invention is directed to a combined separation and stripping process, wherein a mixture of fluid catalytic cracking catalyst is separated from a catalyst containing gaseous hydrocarbon effluent of a fluid catalytic cracking (FCC) reactor zone and wherein any hydrocarbons are stripped from the separated catalyst particles in a fluidized bed zone to which a gaseous stripping medium is supplied to.

Such a combined FCC separation/stripping process is described in WO-A-9742275. This publication describes the separation of catalyst particles from a gaseous stream leaving a reactor riser of a fluid catalytic cracking (FCC) process. The separation is performed by making use of a cyclone apparatus located in a reactor vessel, in which cyclone the gas-solids stream enters tangentially into a vertical tubular cyclone housing. The solids are discharged downwards to a stripping zone located at the lower end of the reactor vessel. A partly cleaned gas stream and part of the stripping gas is discharged upwards through a vertical gas-outlet conduit, which gas-outlet conduit protrudes the cyclone tubular housing from above. The solids still present in the partly cleaned gas obtained are subsequently separated in a second cyclone apparatus. The lower open end of the tubular cyclone housing projects downwards into a fluidized-bed zone present in the lower part of earlier mentioned reactor vessel. Stripping gas is supplied to the main fluidized bed zone. Because the tubular housing of the cyclone separator is smaller than the reactor vessel only a part

of the stripping gas will enter the tubular cyclone housing from below.

US-A-4692311 describes a combined process for separating and stripping FCC catalyst in which all of the stripping gas is discharged through the gas outlet of the first cyclone separator. This is achieved by using a cyclone having a tubular housing and a single stripping zone located in the lower portion of said tubular housing. In this manner all of the stripping gas will have to leave the apparatus via the gas-outlet of the cyclone separator. Although this process may look promising regarding the simplicity of the design no large scale working examples have been realised up till now. This is because the separation efficiency is poor when a large flow of stripping gas has to pass through the tubular housing of the cyclone.

Cyclone separators having a vertical tubular housing, a frusto-conical lower portion, wherein the smaller end is located at the lower end, and an gas-outlet conduit having a gas-inlet opening located at about the level of the cyclone roof are described Chemie Ingenieur Technik (70) 6 1 98, pages 705-708. Although promising separation efficiencies are reported no indication is given in this article that the same results will be achieved when a stream of additional (stripping) gas is fed to the lower portion of a cyclone separator having a tubular housing.

The object of the invention is a process for the combined separation and stripping of a mixture of fluid catalytic cracking catalyst in a fluid catalytic cracking process, in which the separation efficiency of the catalyst is higher.

Summary of the invention

Apparatus for combined separation and stripping of a suspension of catalyst particles and vapour in a

fluidized catalytic cracking process, wherein the apparatus includes:

(i) a vertical primary cyclone vessel, which primary cyclone is provided with a tangentially arranged inlet for receiving the suspension of catalyst particles and vapour, which primary cyclone has a tubular side wall and is open at its lower end and closed at its upper end by means of a cover provided with an opening, wherein the outlet opening is fluidly connected to a gas outlet conduit, which conduit has a gas inlet opening located at about the same level as the opening in the cover;

(ii) a stripping zone which zone is provided with means to supply stripping gas, so arranged that in use a fluidized bed is present, located such that part or all of the stripping gas leaving the stripping zone in an upward direction enters the lower end of the primary cyclone; and

(iii) one or more secondary gas-solids separators which are in fluid connection with the gas outlet conduit of the primary cyclone.

In the apparatus according to the invention a fluidized catalytic cracking process having a good separation efficiency can be performed. The apparatus requires less additional means to discharge stripping gas or can be used with a higher stripping gas loading while the separation efficiency remains within the desired range. This was not possible with the above described prior art apparatuses.

The invention is also directed to a fluidized catalytic cracking process making use of said apparatus. The invention shall be described in more detail below, including some preferred embodiments.

Detailed description of the invention

The present process is directed to an apparatus to be used to separate and strip catalysts in a fluid catalytic

cracking process. Examples of such a fluid catalytic cracking process are described in Catalytic Cracking of Heavy Petroleum Fractions, Daniel DeCroocq, Institut Francais du Petrole, 1984 (ISBN 2-7108-455-7), pages 100-114.

In a catalytic cracking process a hydrocarbon feed is contacted with a catalyst at elevated temperatures for a short period. Normally the catalyst and the hydrocarbon feed flow co-currently through a tube-like reactor. These pipe-like reactors are also referred to as riser reactors because in most cases the reactants flow in an upward motion. Although the term riser is used in this description it does not mean that the invention is limited to embodiments comprising risers through which the reactants flow in an upward direction. Contact times in the riser reactor are generally in the range of between 0.5 and 5 seconds. In the reactor riser hydrocarbons having generally a normal boiling point above 350 °C are converted to lighter products, for example gasoline being one of the major products of a FCC process. Hydrocarbons and coke will deposit on the catalyst particles. During stripping a major portion of the deposited hydrocarbons will be separated from the catalyst. The gaseous mixture of hydrocarbons and stripping medium will be discharged from the stripping zone via the tubular housing of the cyclone. The coke is subsequently separated from the thus stripped catalyst by, optionally partial, combustion in a regenerator vessel. The regenerated catalyst, having an elevated temperature is returned to the bottom of the reactor riser.

Preferred embodiments shall be illustrated by making use of the figures 1, 2, 3 and 4. It should be noted that the preferred dimensions are not limited to the specific embodiment for which the dimensions are explained.

Figure 1 represents an apparatus according to the invention having an external fluid catalytic cracking reactor riser and an external secondary gas-solids separator. With external is here meant external from the primary cyclone and stripping zone vessels. Figure 2 is a detail of a preferred interface between primary cyclone and the stripping zone of the apparatus of Figure 1. Figure 3 is a variation of the apparatus of Figure 1. Figure 4 represents an apparatus in which reactor riser, primary separation means and stripping zone are contained within one vessel.

In Figure 1 a vertical arranged tubular vessel (1) is shown consisting of the primary cyclone (2) as the upper part and the stripping zone (3) as the lower part. The primary cyclone (2) has a tangentially arranged inlet (4) for receiving the suspension of catalysts and vapour. This inlet is in fluid communication with the FCC reactor riser (5), allowing catalyst and vapour leaving the reactor riser (5) to enter the primary cyclone (2). The tubular housing of primary cyclone (2) has an opening (6) at its lower end and a cover (7) at its upper end. The cover (7) is provided with an opening (8). This opening (8) is fluidly connected with conduit (9) through which cleaned vapours can be discharged from the cyclone housing. The gas inlet opening (10) of conduit (9) is located at about the same level as the opening (8) in cover (7). It has been found to be advantageous that the inlet opening of conduit (9) is located at some distance (d1) above the center of the tangentially arranged inlet opening (4). The ratio of this distance and the diameter of the tubular housing (d2) is preferably between 0.5 and 1.5. It is even more preferred that the gas inlet (10) of conduit (9) is formed by the opening (8) in cover (7) as shown in Figure 1. This is advantageous because the tubular cyclone housing will

include less surface on which carbon deposits can accumulate. In the primary cyclone (2) the separation takes place between the major part of the catalysts and the gaseous hydrocarbons. The catalyst falls down via the open lower end (6) of the primary cyclone into a stripping zone (3).

The conduit connecting tangentially arranged inlet (4) and the riser (5) is preferably made at an angle of 90° with respect to the riser (5). However in order to eliminate accumulation of catalyst in this horizontal connecting conduit it can be advantageous to place this conduit at an angle less than 90°, preferably between 89° and 75°. It has also been found to be advantageous to have a smaller cross sectional area at inlet (4) relative to the cross sectional area of the connecting conduit at a point nearer to the riser (5).

Preferably a vortex stabiliser (11) is provided at the interface between the primary cyclone and the stripping zone. The vortex stabiliser is suitably a circular flat plate or cone-shaped disk. The diameter of the vortex stabiliser suitably is greater than the diameter (d3) of the gas inlet opening of the gas outlet conduit (9). The diameter of the vortex stabiliser (11) should be small enough to provide an annulus between the perimeter of the vortex stabiliser and the wall of the tubular housing, which annulus permits catalysts to flow downwards while simultaneously passing stripping gas in an upwards direction. The vortex stabiliser is preferably positioned at a distance (d4) below the gas inlet opening (10) of gas outlet conduit (9), wherein (d4) is between 2 and 5 times the diameter (d2) of the tubular housing. The vortex stabiliser is preferably provided further with a vortex finder (12). A vortex finder (12) is a vertical positioned rod having a length of about between 0.25 to 1 times the diameter (d3) of the gas

inlet opening of the gas outlet conduit (9). A suitable vortex stabiliser and vortex stabiliser rod are for example described in the above mentioned US-A-4455220. The vortex finder rod may suitably be a hollow tube resulting in a fluid connection of the space above the vortex finder and the space below the vortex finder. The hollow vortex finder rod will allow upwards moving gas to pass, thereby enhancing the stabilising effect on the vortex present in the primary cyclone.

In stripping zone (3) a fluidized bed (13) is present in which catalyst are stripped from the hydrocarbon deposits by supplying stripping gas via stripping gas supply means (14). Stripping gas is suitably steam. The stripping zone may suitably have more than one stripping gas supply means located at some distance above each other. The stripping zone includes a dense phase, in which the catalyst are kept in a dense fluidized bed mode by means of the stripping gas and a dilute phase located above the dense phase. The boundary between the two phases is formed by fluidized bed level (15). Through conduit (16) stripped catalyst are transported to a catalyst regenerator (not shown). The stripper may contain internals to enhance the stripping efficiency. Preferably the height of the stripping bed, being the distance between the lowest positioned stripping gas supply means and the fluidized bed level (15) is at least 3 times the average diameter of the stripping zone (3). The superficial steam velocity in the fluidized bed is preferably between 0.05 and 1 m/s, and more preferably between 0.1 and 0.7 m/s.

The gas outlet conduit (9) is in fluid connection with one or more, preferably 2-4 secondary gas-solids cyclones (only one secondary cyclone shown in figure 1 as (17)) via conduit (18) and optionally one or more other conduits (18'). The catalyst which is removed from the

vapours in the secondary cyclone will be transported to the stripping zone (3) via dipleg (19). The cleaned vapours are discharged via conduit (20) for further processing.

Preferably a tube (21) is placed alongside the vortex stabiliser as shown in Figure 2. The annular space (22) which is formed by the tube (21) and the tubular wall of the primary cyclone provides an opening through which catalyst can flow downwards (Figure 2a). Stripping gas can flow upwards through the annular space (23) formed by the inside of tube (21) and the perimeter of the vortex stabiliser (11). In this configuration the downwards moving catalysts will be less disrupted by the upwards moving stripping gas. The dimensions of tube (21) are chosen such that the upper opening of annular space (22) is at a position where sufficient catalyst separation has taken place. Preferably the distance (d5) between the top of tube (21) and the center of the tangentially arranged inlet (4) is between 0.5 and 1.5 times the inner diameter (d2) of the primary cyclone. The height of tube (21) is less critical. The lower opening of annular space (22) is suitably at some distance (d6) below the fluidized bed level (15). A suitable distance (d6) is between 0 and 0.5 times inner diameter (d2) of the primary cyclone. The height (D7) of tube (21) is preferably between 0.5 and 1 times the inner diameter (d2) of the primary cyclone. The diameter of tube (21) is preferably such to provide a sufficiently large annulus (23) between the perimeter of the vortex stabiliser and the inner wall of tube to permit stripping gas to flow upwards and a sufficiently large annulus (22) to permit catalysts to flow downwards. More preferably this diameter is 0.7 to 0.9 times (d2).

In the apparatus shown in Figure 1 all the stripping gas is discharged from the stripping zone via the primary cyclone to the gas outlet conduit of the primary cyclone

because the primary cyclone and stripping zone together form one tubular vessel. Although this is a preferred embodiment of the invention, other embodiments can also be envisaged, wherein only part of the stripping gas is discharged via this opening (6) and wherein the advantages, namely an improved separation of solids and gas, are also achieved. Examples of such embodiments of the invention are illustrated by Figures 3 and 4.

In Figure 3 an embodiment is shown wherein the lower part of the tubular stripping zone (3) protrudes a larger tubular vessel (27) from above. The lower end of the tubular stripping zone (3) is in fluid communication with the interior of vessel (27). In vessel (27) additional means (24) for supplying stripping steam are present. At the top of vessel (27) a conduit (26) is present through which part of the stripping steam can be discharged. This conduit (26) is suitably in fluid communication with the downstream part of reactor riser (5) or with the gas outlet conduit (9) or (18). The larger tubular vessel provides, in use, a secondary stripping zone (25') next to the primary stripping zone (25). The dipleg of the secondary cyclone is preferably in fluid communication with the secondary stripping zone. This embodiment may also be equipped with a tubular part shown as (21) in Figure 2. The embodiment of Figure 3 can advantageously be obtained by a simple modification of the primary cyclone (2) of an existing FCC reactor vessel.

Figure 4 illustrates an apparatus for the separation of catalyst particles from a gaseous stream wherein one or more primary cyclones, secondary cyclone(s) and the stripping zone are located in a reactor vessel having a larger diameter than the primary cyclone. The reactor vessel is furthermore provided with inlet and outlet means to supply the suspension of catalytic particles and vapour and means to discharge stripped catalyst and

vapours essentially free of catalyst particles. The inlet means to supply the suspension of catalytic particles to the primary cyclone is in fluid connection with the downstream end of a reactor riser (28) of a fluid catalytic cracking (FCC) process. Such a downstream end of a reactor riser (28) may be positioned within (as shown) or outside the reactor vessel (30). The primary cyclone (29) is located in a reactor vessel (30), in which cyclone (29) the gas-solids stream enters tangentially into a vertical tubular cyclone housing. The solids are discharged to a primary stripping zone (31) located at the lower end of the reactor vessel (30). A partly cleaned gas stream and part of the stripping gas is discharged upwards through a vertical gas-outlet conduit (32), which gas-outlet conduit does not protrude the primary cyclone roof (33) from above, according to the present invention. The solids still present in the partly cleaned gas obtained are subsequently separated in a second cyclone apparatus (34). The primary stripping zone (31) is formed by the open lower end of the tubular housing of the primary cyclone (29) projecting downwards to a point below the fluidized bed level (41) of a main fluidized-bed zone (35) present in the lower part of earlier mentioned reactor vessel (30). Stripping gas is supplied to the primary and main fluidized bed zone by means (37) and optionally by means (36). Because the tubular housing of the primary cyclone (29) is smaller than the reactor vessel (30) only a part of the stripping gas will leave the reactor vessel (30) via conduit (32). The remaining part of the stripping gas will leave the vessel (30) via slit (38) present in the gas outlet conduit (32), secondary cyclone (34) and the secondary cyclone gas outlet (39). Catalyst separated in secondary cyclone (34) are returned to the main stripping zone (35) via dipleg (40). The primary cyclone (29) may

additionally be equipped with a vortex stabiliser (11) and a tube (21) as shown in Figure 1 and 2. The embodiment of Figure (4) can advantageously be obtained by a simple modification of the primary cyclone of an existing FCC reactor vessel. An example of a known FCC reactor vessel is described in the afore mentioned WO-A-9742275.

Although the secondary cyclones in figures 1, 3, and 4 are shown as conventional reverse flow cyclones, there is an advantage in omitting the protrusion of the gas-outlets (20) into the cyclone housing. This is advantageous in order to avoid coke-attachment around such a protrusion. As for the primary cyclone it is also advantageous that the inlet opening of conduit (20) of the secondary cyclone (17) is located at some distance above the center of the tangentially arranged inlet opening in the secondary cyclone (17). The ratio of this distance and the diameter of the tubular housing of cyclone (17) is more preferably between 0.5 and 1.5.

CLAIMS

1. Apparatus for a combined separation and stripping of a suspension of catalyst particles and vapour in a fluidized catalytic cracking process, wherein the apparatus includes:

(i) a vertical primary cyclone vessel, which primary cyclone is provided with a tangentially arranged inlet for receiving the suspension of catalyst particles and vapour, which primary cyclone has a tubular side wall and is open at its lower end and closed at its upper end by means of a cover provided with an opening, wherein the outlet opening is fluidly connected to a gas outlet conduit, which conduit has a gas inlet opening located at about the same level as the opening in the cover;

(ii) a stripping zone which zone is provided with means to supply stripping gas, so arranged that in use a fluidized bed is present, located such that part or all of the stripping gas leaving the stripping zone in an upward direction enters the lower end of the primary cyclone; and

(iii) one or more secondary gas-solids separators which are in fluid connection with the gas outlet conduit of the primary cyclone.

2. Apparatus according to claim 1, wherein the gas inlet opening of the gas outlet conduit is located at a distance (d1) above the center of the tangentially arranged inlet opening and wherein the ratio of this distance and the diameter of the tubular housing (d2) is between 0.5 and 1.5.

3. Apparatus according to any one of claims 1-2, wherein the gas inlet opening of the gas outlet conduit is formed by the opening in the cover of the primary cyclone.

4. Apparatus according to any one of claims 1-3, wherein a vortex stabiliser is provided at the interface between the primary cyclone and the stripping zone.

5. Apparatus according to claim 4, wherein a tube is placed alongside the vortex stabiliser in which an annular space is formed by the tube and the tubular wall of the primary cyclone providing an opening through which, in use, catalyst can flow downwards and wherein stripping gas can flow upwards through the annular space formed by the inside of tube and the perimeter of the vortex stabiliser.

6. Apparatus according to any one of claims 1-5, wherein the primary cyclone vessel and the stripping zone together form one tubular vessel, wherein in use, all of the stripping gas will be discharged from the stripping zone via the primary cyclone to the gas outlet conduit of the primary cyclone.

7. Apparatus according to any one of claims 1-5, wherein one or more primary cyclones, secondary cyclones and the stripping zone are located in a reactor vessel having a larger diameter than the primary cyclone, wherein the reactor vessel is also provided with means to supply the suspension of catalytic particles and vapour and means to discharge stripped catalyst and vapours essentially free of catalyst particles.

8. Use of an apparatus according to any one of claims 1-7 in a fluid catalytic cracking process.

9. Method to retrofit an existing FCC process apparatus to obtain an apparatus according to any one of claims 1-7, wherein the existing primary cyclone has a gas-outlet tube protruding the tubular housing of the cyclone.

C41/TS0766PD

ABSTRACT

COMBINED SEPARATION AND STRIPPING PROCESS

Apparatus for a combined separation and stripping of a suspension of catalyst particles and vapour in a fluidized catalytic cracking process, wherein the apparatus includes:

(i) a vertical primary cyclone vessel, which primary cyclone is provided with a tangentially arranged inlet for receiving the suspension of catalyst particles and vapour, which primary cyclone has a tubular side wall and is open at its lower end and closed at its upper end by means of a cover provided with an opening, wherein the outlet opening is fluidly connected to a gas outlet conduit, which conduit has a gas inlet opening located at about the same level as the opening in the cover;

(ii) a stripping zone which zone is provided with means to supply stripping gas, so arranged that in use a fluidized bed is present, located such that part or all of the stripping gas leaving the stripping zone in an upward direction enters the lower end of the primary cyclone; and

(iii) one or more secondary gas-solids separators which are in fluid connection with the gas outlet conduit of the primary cyclone.

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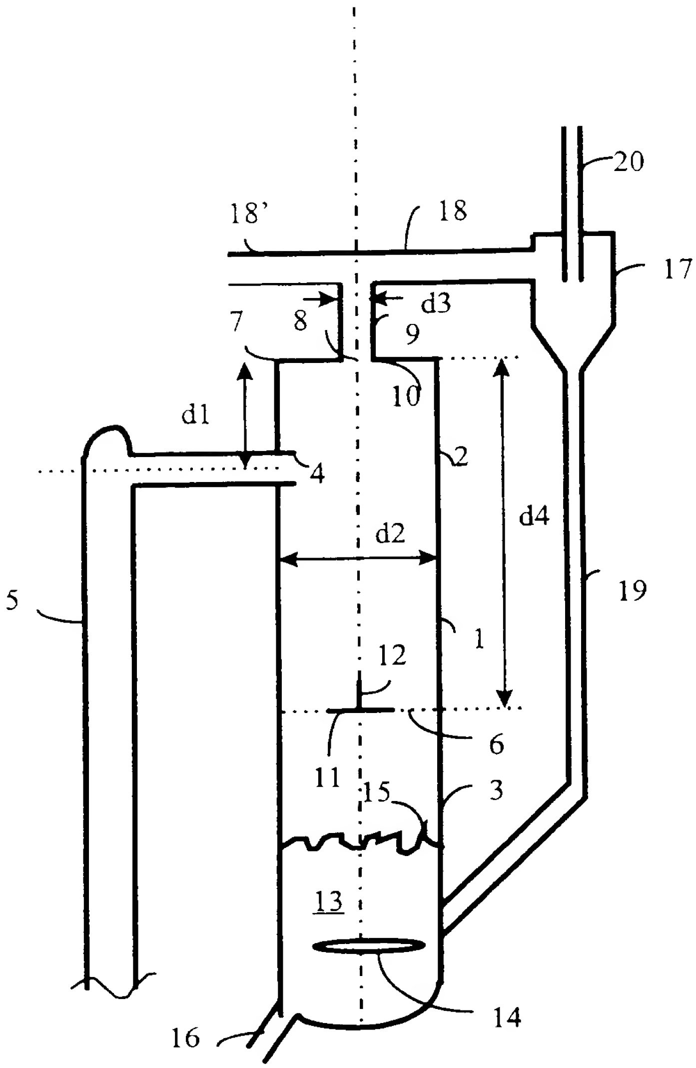

Fig.1

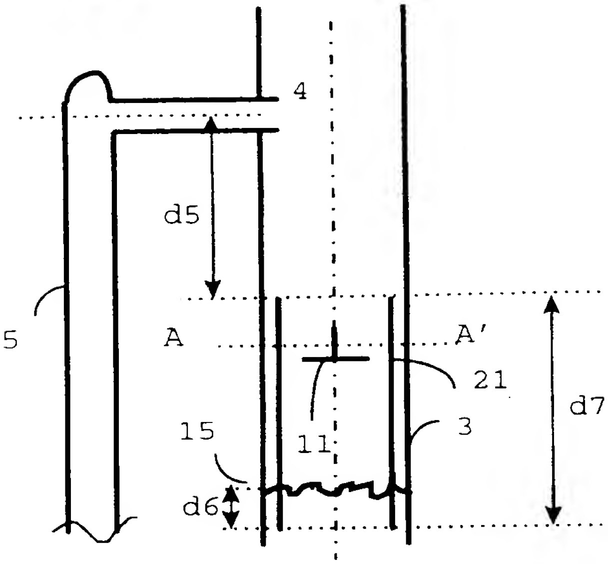

Fig. 2

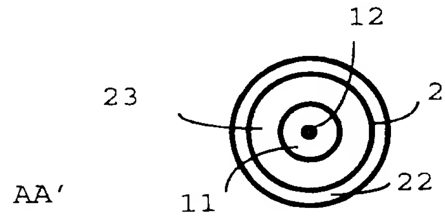

Fig. 2a

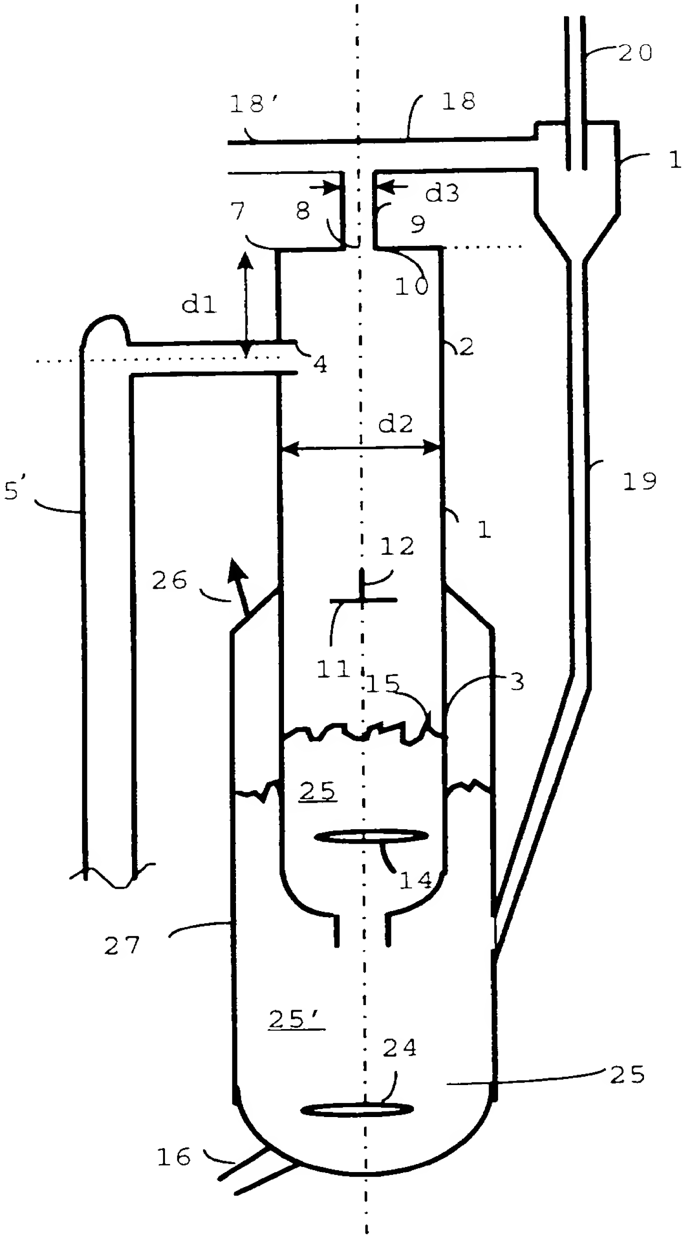

Fig.3

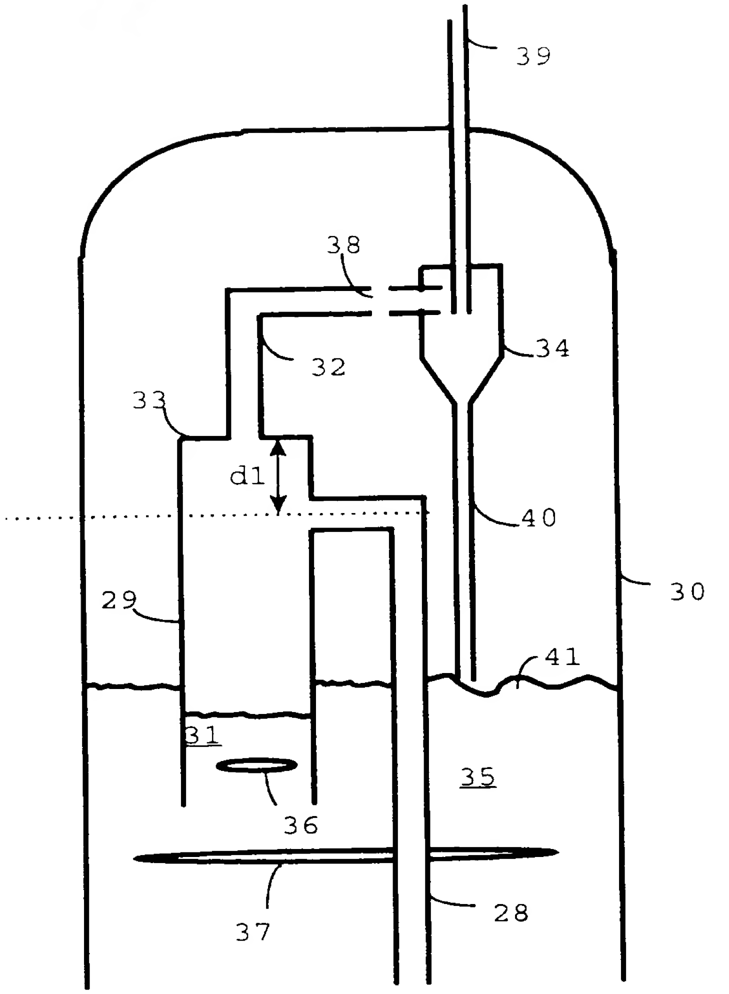

Fig. 4